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HWA Project No. 2005-027

Atelier Landscape Architects
120 Belmont Ave East
Seattle, Washington 98102-5603

Attention: Mr. Alex Shkerich

Subject: **PRELIMINARY GEOTECHNICAL INVESTIGATION**
Burke-Gilman Trail Redevelopment
NE 145th Street to Logboom Park
King County, Washington

Dear Alex,

This report presents our conclusions regarding potential geotechnical issues with redevelopment of the Burke-Gilman Trail along the subject section. We understand the County plans to redevelop the trail. Proposed improvements include widening the paved trail and providing a separate soft surface trail. The 2.3-mile long section of trail is located in Lake Forest Park and Kenmore, from the NE 145th Street alignment (boundary with City of Seattle) to Logboom Park in Kenmore.

Our understanding of the geotechnical issues for widening the trail in the subject section are based in part on our previous familiarity of the trail and surrounding areas, pre-design and design work conducted by HWA for other regional trails, a previous landslide study by HWA for the southern 500 feet or so of this section, and a limited reconnaissance of this section by HWA geologists on March 29, 2005.

EXISTING SITE CONDITIONS

The trail is parallel to, and a short distance from, the northwestern shore of Lake Washington, on a former railroad right of way. The trail gradient is generally flat, and at an elevation of around 35 feet. The trail at present consists of a 10-foot wide asphalt pavement, typically with a grass shoulder on one or both sides. In most areas the grass shoulder slopes away from the pavement, at various inclinations, from flat to 3H:1V (Horizontal:Vertical). In some cases the ground slopes steeply into a ditch, starting right at edge of pavement. In general, the width of the top of the old railroad bed is on the order of 11 to 16 feet, with considerable variation in short distances along the trail.

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Houses are present adjacent to the lake side of the trail along most of the section. On the upslope side, houses are farther from the trail, though near the top of the adjacent slopes. Streets and driveways both intersect, and are in close proximity, with the trail. The topographic configuration of the trail falls under the following scenarios when headed north on the trail:

1) **Uphill cut slope on left downhill fill slope on right:** This configuration is present along the majority of the section. The uphill slopes vary from a steep, high bluff at the south end (chronic landslide area in the southern 500 or so feet), to moderately steep slopes up to 50 feet high, to 10 to 15 foot high cuts with shallow slopes. The steep cut slopes appear to be within dense to very dense soils, with a thin covering (1/2 to 1 foot) of loose soil, derived from weathering and raveling of the slope (colluvium). At higher slopes with a shallow toe adjacent to the trail, the toe consists of an accumulation of colluvium and /or slide debris. A portion of the trail has a 10 to 15 foot high slope with the 10 to 15 foot high concrete retaining wall for Bothell Way at the top. A drainage ditch is present adjacent to the trail at the toe of the uphill slope. The downhill fill slope ranges from 2 to 10 feet high, and in most cases ranges between 4 and 8 feet. Where bordered by driveways or streets, the fill is retained by some type of wall, typically a concrete block wall or rockery. Where the slope is into a yard or natural area, it typically consists of a vegetated slope at an inclination from 1½ H:1V to 3H:1V.

2) **Downhill slope on both sides:** From the vicinity of NE 170th Street northeastward to just past Ballinger Way, the adjacent ground is at approximately the same grade as, to somewhat lower than, the trail. Deep, wet ditches are present on the left side in places, and McAleer and Lyon Creeks are crossed by the trail.

Geology

In general, the surficial geology in the study area consists of dense to very dense, glacially consolidated deposits forming the steep slopes, with loose to medium dense deposits derived from post-glacial erosion and landsliding forming colluvium in the low areas. The trail is atop the old track alignment, which is built on cuts into the dense soils and fills built over dense soils, as well as over loose colluvium, alluvium, and beach deposits.

Geologic information for the trail section was obtained from the *Preliminary Geologic Map of Seattle and Vicinity, Washington* (Waldron et al, 1962) and *Geologic Map of the Edmonds East and Part of the Edmonds West Quadrangles, Washington (Minard, 1983).*

Various geologic units are encountered along the project corridor. Very few geologic units have precise boundaries. The geology of an area can change drastically, both horizontally and vertically, within a few feet or, in some instances, can remain fairly consistent for hundreds of feet. In general, glacially consolidated, dense to very dense deposits are present within cuts and natural slopes upslope from the trail, and colluvium, alluvium or beach deposits are present downslope from the trail.

Geologic Hazards

The southern portion of the trail section, from NE 145th to approximately NE 162nd Street, is within a Landslide Hazard Area as mapped in the King County Sensitive Areas Map Folio.

The northern portion of the trail section, from approximately NE 162nd Street to Logboom Park, is through a Seismic Hazard Area as mapped in the folio. Seismic hazard areas are generally defined as areas subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction. Seismically induced liquefaction typically occurs in loose, saturated, sandy material commonly associated with recent stream, lake, and beach sedimentation, as well as with loose saturated fill.

GEOTECHNICAL DESIGN AND CONSTRUCTION CONSIDERATIONS

Redevelopment of the trail by constructing a wider paved trail and a separate soft surface trail may require widening of the existing trail bed / old railroad bed. This widening can be accomplished by placing fill on the downslope side, cutting into the upslope side, or a combination of the two. Downslope filling would, at most locations, require a retaining wall parallel to the trail due to right of way limitations. Upslope cutting would definitely require retaining walls since there is no place where the slope can be cut back to the top without impacting neighboring land. There are no significant geotechnical issues with widening in either direction. Both slope stability and drainage issues can be mitigated by proper design. However, cutting into the upslope side poses a potential liability risk. Once the toe of a steep slope is cut into, even when adequately retained, slides may still occur along the slope above and property owners might blame the cut and wall. Using the appropriate seismic design parameters in design can reduce the impact of seismic shaking on the redeveloped trail. Liquefaction susceptibility at critical structures should be identified by the geotechnical subsurface investigations during the design phase.

Downslope Widening

Widening the trail on the downslope side can be accomplished with fill, either retained by a wall or sloped to a stable inclination. Geotechnical issues with downslope widening include the potential for differential settlement of new fill where it adjoins existing grade, which may result in pavement cracking and settling. This possibility can be prevented with design of the fill, and proper fill placement and compaction methods during construction. Also, improper placement of fill over a slope can result in slope failure. This can be prevented with proper geotechnical design of the earthwork and retaining walls, and construction methods and performance that meet the design criteria.

Widening without the need for a retaining wall may be accomplished where there is sufficient width for placement of fill with a maximum sideslope inclination of 2H:1V. Fill placement would require removal of vegetation and organic soils, and benching the existing ground such that fill can be placed on level ground in horizontal lifts.

Upslope Widening

Widening by cutting into the existing uphill slope is complicated by two factors:

1) Maintaining adequate surface water and ground water drainage; and
2) The potential for destabilizing the slope downhill from existing homes or driveways.

Cuts into the slope may result in needing to export unsuitable soil and needing to import structural fill and/or drainage material.

Upslope widening would likely require moving or reconfiguring the existing ditch (see the "Drainage" section below). A drainage ditch would need to be maintained at the toe of the wall. Drainage measures behind the wall would be needed to capture ground water seepage.

Wall design will need to consider the potential for seasonally high runoff and ground water seepage volumes infiltrating into the wall backfill. For slopes significantly higher than the proposed wall, it is best to avoid cutting the wide footprint needed for an MSE or gravity wall. Soldier pile and lagging walls are preferable for such cuts, as the piles can be installed prior to cutting the slope, and the cut will only extend horizontally to between the piles, reducing potential impacts to the slope. For cuts that will be as high as the slope, or most of the height (e.g. steep slopes 10 feet high or less, with flat or gently sloping ground above), gravity walls could be considered. Concrete cantilevered walls may be suitable in this situation as well.

Potential Retaining Walls

There are numerous types of walls, each with its own advantages and disadvantages, depending on engineering considerations such as retained earth properties, foundation conditions, height, construction access and water. Outside influences such as property ownership, cost, and aesthetics are also factors.

Gravity Walls: There are many readily available alternatives for gravity walls. Some of the more common types include filled units such as gabion baskets; segmental concrete units such as Ultra-block, Lock-Block, or ecology blocks, and large rocks (rockeries). These walls are typically excavated in short segments (along the length of the wall) and the units are then placed with compacted backfill behind the wall. This type of wall is particularly well suited to areas with a minimum backslope and space for construction behind the wall. Stability of these walls depends on the inherent stability of the cut slope, e.g. slopes with stability issues should not be retained with gravity walls.

Mechanically Stabilized Earth (MSE) Walls: MSE walls include any wall that relies upon the interaction between a mechanical device (such as geogrid) and the soil to stabilize the soil and allow it to stand near vertical. A common type of MSE wall is a geogrid reinforced segmented masonry unit (SMU) wall such as Mesa, Lock-Block, or Keystone. The wall site is prepared by clearing and grubbing the wall and fill footprint. If unsuitable soils are exposed at the wall footing, they are removed and replaced with structural fill. Generally the over-excavation is limited to immediately under the footprint of the wall. If the wall footing is in a low-lying area, localized dewatering, typically with sumps and pumps in the excavation, may be required.

One of the requirements for MSE walls is the need for adequate room behind the wall to lay out the reinforcing. For some of the potential wall locations, additional room may need to be created (i.e., soil removed) in order to install the reinforcing. Alternatively, anchors are sometimes used to hold the back of short reinforcing. Generally, the reinforcing is tied into the facing units and holds the facing up. The sequence for construction can involve placing the reinforcing, backfilling and compacting a lift of fill, placing another layer of reinforcing, tying it into the facing, backfilling on top of the second layer of reinforcing, and repeating.

MSE walls are particularly well suited for use as high walls where there is, or can easily be made, a wide bench on which to construct the wall. They will work under some circumstances where the foundation soils are marginal. Advantages of MSE walls include non-specialized construction, neat appearance, and ability to withstand differential settlement without failure. Disadvantages include the need for placing geogrid behind the blocks a distance equal to about 3/4ths the height of the wall. This would require excavating into the existing fill embankment or cut slope. For higher downslope walls, the excavation may extend into existing utilities within the trail bed. For less than about 3 feet in total height, it may be possible to eliminate the geogrid.

Concrete Cantilever Walls: Cantilever walls are constructed by building a concrete structure on a prepared surface and backfilling behind. They are particularly well suited for low walls where the foundation conditions are good. The necessary footprint behind the wall is typically narrower than for an MSE or gravity wall.

Soldier Pile and Lagging Walls: Soldier pile and lagging walls are constructed by installing vertical soldier piles and then placing lagging to hold back the soil between the piles. These walls derive their support from lateral pressure on the soldier piles below the front of the wall. They are particularly appropriate where there is limited area for structure behind the wall face. They can be constructed from either the top or bottom of the wall so the disturbance on the other side can be minimized. The soldier piles are usually either driven, auger-cast or cast in place piles placed on 4 to 8-foot spacing. Driven piles are usually H-piles. Driven piles can create construction vibrations and possibly settlement near the pile. Auger-cast and cast in place piles are drilled and cause less vibration. If necessary, the hole may be cased with the auger, a steel pipe, or filled with drilling fluid. Drilling fluid is usually a naturally occurring bentonite clay-based mud. Steel, usually an H-pile, is placed in the augured hole and structural concrete is tremied down, as the casing is lifted or the drill fluid is displaced. If drilling mud is used, there is a discharge of bentonite mud in a contained area on the ground surface that must be removed.

Sheet Pile Walls: Sheet pile walls may be used if the ground is soft. The sheet piles are usually driven with a vibratory hammer which creates significant vibration.

Drainage

Existing ditches may need to be partially filled in some areas. In many areas, slough and eroded soils that have partially filled the ditch will need to be removed to obtain the preferred ditch geometry. In either case, the adequacy of surface water drainage along the trail vicinity will depend on maintaining the ditches at the preferred depth range. Subgrade strength and therefore integrity of the trail pavement will also depend on keeping the trail bed in an unsaturated condition to a minimum of about 18 inches below pavement finish grade.

We recommend that ditch fill consist of compacted, structural fill. Prior to placement of the fill, existing vegetation, organic soils, and slough should be removed from the ditch. Structural fill for the new ditch bottom should then be placed and compacted in horizontal lifts. Fill placed for shallower sideslopes should be overbuilt, then trimmed to a 2H:1V inclination, and protected with long-term erosion control measures.

Existing Landslide Area

The existing slide area at the southern end of the section exhibits the worst case scenario. A cut into this slope should only be retained by a soldier pile wall, possibly with tiebacks, and would need some regrading of the slope above and structural fill placement behind the wall to improve stability of the slope (per our report dated 2/18/02). Cutting into this slope and constructing a retaining wall would not result in decreased slope stability; nor would the wall prevent future slides coming down from above.

Bridges

The existing bridges over McAleer and Lyon Creeks have decks that are 12 and 8 ½ feet wide, respectively. Either the bridge structures would need to be rebuilt wider over the existing foundations, or the bridges would need to be completely rebuilt. If new foundations are necessary, the bridge foundations may be either driven, auger-cast, or cast in place piles. The driven piles could be H-piles, pipe piles, timber piles, or pre-cast concrete piles. Selection of pile type, size, and spacing would depend upon the soil properties, potential for obstructions, design loads, and availability of construction equipment and materials. Impacts from driving piles would be vibrations and noise. Driving piles requires large construction equipment and a laydown area nearby. The biggest impact of constructing auger cast or cast in place piles is the removal and disposal of native materials and perhaps drilling mud.

Pavements

Settled pavements were observed in a few areas, within the outer couple of feet of the downslope side of the trail, in a linear fashion – e.g, settlement appears to have occurred along utility trench backfill. The potential for differential settlement between new fill and existing trail grade can be reduced by removing all of the old pavement, and proof-rolling to identify any soft areas (which can be improved by over-excavation and replacement with structural fill).

Access to, and along, the existing trail with dump trucks and heavy equipment will need to be considered. Pavements on the existing trail, as well as streets and driveways used for access, are likely to experience distress from construction traffic.

LIMITATIONS

We have prepared this preliminary report for Atelier Landscape Architects and King County Parks for use in pre-design of a portion of this project. Experience has shown that soil and ground water conditions can vary significantly over small distances and there was no subsurface exploration done for this study. Therefore variations from the information presented herein should be expected.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, expressed or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or ground water at this site.

We appreciate this opportunity to be of service.

HWA GEOSCIENCES INC.

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